III. Major Laboratory Initiatives

The Laboratory's second strategic objective is stated in Chapter II: "Argonne will develop important new R&D initiatives and scientific facilities that serve emerging national needs consistent with its mission and will implement them cost-effectively and expeditiously to the benefit of DOE and the nation." This chapter provides planning "snapshots" of Argonne's major Laboratory initiatives, for consideration by DOE.[1] The Laboratory's initiatives represent important opportunities to enhance U.S. research capabilities, to serve the broader scientific community, and to advance scientific understanding and engineering achievement across a wide range of disciplines.

Argonne carefully considers the implications of the National Environmental Policy Act (NEPA) for its scientific and technical initiatives, as early as it is reasonable to do so. For initiatives where NEPA implications are expected to be significant, the implications are discussed explicitly in this *Institutional Plan*.

The five major Argonne initiatives relate most closely to two DOE mission areas, Science and Energy:

- Science
  - Nanosciences and Nanotechnology — Center for Nanoscale Materials
  - Rare Isotope Accelerator
  - Functional Genomics
  - Petaflops Computing and Computational Science
- Energy
  - Advanced Nuclear Fuel Cycle

[1] Inclusion of initiatives in this chapter does not necessarily imply approval, or an intention to implement, by DOE. All funds received for initiatives during FY 2002 are included in the resource tables in Chapter VI of this *Institutional Plan*. However, resources required for proposed growth of initiatives in years beyond FY 2002 are generally not included in those projections. Projected resource requirements for all initiatives include costs associated with protection of the environment and the health and safety of workers and the public.

A. Science

1. Nanosciences and Nanotechnology — Center for Nanoscale Materials

The National Nanotechnology Initiative is an interagency effort driven by the realization that present-day materials and processes are reaching their limits of performance. Fundamentally new approaches are needed to transcend these limits. The emerging field of nanoscience offers the requisite scientific and technological opportunities. Accordingly, DOE has taken the bold step of establishing five new Nanoscale Science Research Centers at its national laboratories. Argonne's Center for Nanoscale Materials (CNM) was approved in FY 2002 as one of the five.

Argonne's vision is to go beyond present-day semiconductor materials and processing methods to create new functional materials on the nanoscale. Highlights of the Laboratory's plan include focusing on chemical methods to self-assemble nanostructures, to pattern nontraditional electronic materials, and to create new probes for exploring nanoscale phenomena. Moreover, the Laboratory aspires to help pioneer the new fields of molecular and magnetic electronics.

The CNM will serve simultaneously as a forefront research center and as a user facility for the regional and national research communities. Previously, DOE's stewardship of the nation's major materials science user facilities (such as the Advanced Photon Source [APS] and Intense Pulsed Neutron Source [IPNS] at Argonne) focused on the advanced *characterization* of materials. The CNM will be part of a new generation of DOE user facilities because its primary goal is to *fabricate* advanced nanoscale materials.

The CNM will complement Argonne's existing user facilities and enhance their value by creating cutting-edge nanomaterials that require advanced characterization. To maximize this synergy, the new building for the CNM will adjoin the APS, and the CNM will construct a state-of-the-art, hard x-ray nanoprobe beamline at the APS. The new beamline will focus hard (i.e., 10 keV) x-rays down to an unprecedented spot size of 30 nanometers. This capability will enable a variety of imaging, spectroscopic, and diffraction experiments that cannot be performed similarly anywhere else in the world.

The signature new technology of the last half of the 20th century was solid-state electronics. The 21st century is expected to be marked by the creation of connections across the biointerface, and a major focus of the CNM will be creating novel interconnections between soft matter (complex organic and biological molecules) and hard matter (solid-state nanoparticles and patterned systems). Major areas of interest will include the flow of chemical energy and the propagation of light. Initial Argonne work in these areas has been supported by Laboratory Directed R&D funding and, more recently, by funding of Argonne proposals in response to the DOE Nanoscale Science, Engineering, and Technology call.

Magnetic nanomaterials hold much promise to advance the future of electronics, despite the fact that magnetic materials are among the oldest of technological materials (starting with the use of lodestones for ships' compasses). Today, magnetic nanomaterials promise to revolutionize computer design. Computers already use magnetic nanosystems in hard disk drives to store and read data, and the data density of such magnetic recording devices is doubling every nine months. In the future, nanomagnetic devices may also be used to control the flow of current in the computer's logic elements, which could enable programmable processors that transcend the fixed architectures of today's circuitry. Such processors could be reconfigured dynamically to optimize performance for the particular task at hand. Currently under industrial development are magnetic random access memories that may ultimately provide nonvolatile electronics, including laptop computers capable of "instant bootup."

Realizing these technological opportunities requires fundamental studies of magnetic materials on the nanoscale. Argonne is positioned to take a leadership role within the DOE system in this challenging area. Work on nanomagnetism at the CNM will create new nanostructures by using chemical methods of self-assembly, as well as lithographic patterning of novel thin-film hybrid systems. Utilizing the spin (magnetism) of the electron, in addition to its charge, is opening the new field of magnetic electronics (spintronics). The mission of the CNM will include spintronics, along with molecular electronics and nanophotonics, in the effort to develop new functionalities at the nanoscale.

The CNM will energize new collaborations and partnerships that broaden the user community throughout the Midwest and the nation. To foster this user community and stimulate feedback from users, general and specialized workshops have been held, and more are being planned. Research themes already covered include the x-ray nanoprobe, neutrons and nanoscience, and industrial microfabrication. The University of Chicago-Argonne Consortium for Nanoscience Research was launched in 2001. Principal investigators from both institutions are cooperating to pursue initial research themes that embrace major focal areas for the CNM. The investigators also have begun ambitious planning for intellectual cross-pollination and educational outreach.

An emerging prime interest for the CNM is the role of theory in creating computational algorithms that simulate nanoscale phenomena. Now under way are efforts to define the scope of a research theme within the CNM dubbed the "Virtual Fab Lab." The objective is to use large-scale computational strategies to transform nanofabrication from an art into a science. The concept of the Virtual Fab Lab in the context of the CNM will be the topic of a future workshop, and it creates linkages with the Petaflops Computing and Computational Science initiative described in Section III.A.4.

The excitement of planning science for the CNM is being enhanced by planning for its infrastructure. The state of Illinois has committed funds for construction of the CNM building. M.W. Zander was selected as the architectural and engineering firm to design the building, and its work has begun. Selection of a firm to oversee construction is under way.

The CNM initiative requires investments in the following three complementary areas:

1. *Personnel.* Argonne's staff includes some of the researchers required for this initiative, and several of the Laboratory's core programs will naturally move in directions complementary to the CNM. Many new staff members with special expertise will be recruited in areas such as self-assembly, lithography, advanced spectroscopies, and imaging. In addition, creation of the Virtual Fab Lab will require critical new staff in the areas of theory and computational nanosciences.

2. *New Tools for Nanofabrication.* Electron lithography and focused-ion-beam lithography are essential tools for fabrication of nanostructures. Also required is equipment for etching, deposition, and other processes. Several of these tools do not exist elsewhere in the Midwest and will strongly attract outside users. Clean rooms and related infrastructure will be developed; nanostructures are much smaller than a speck of dust, and scrupulously clean conditions are needed for their fabrication.

3. *New Tools for Nanocharacterization.* Tools for visualizing nanostructures, especially microscopes (x-ray, electron, scanning probe, and near-field optical), will be further developed at Argonne. The x-ray nanoprobe will be developed to use the brilliance of the APS to probe at the nanoscale. The Laboratory's Electron Microscopy Center (Section IV.A.1.b) will be enhanced by synergies with the CNM, and the IPNS will attract new users because of new materials created by the CNM.

Resources required for this initiative are summarized in Table III.1. Argonne is working with the state of Illinois to construct the building for the CNM by January 2006. Further funding for instrumentation and research operations is being sought from DOE-Basic Energy Sciences (DOE-BES; KC-02, KC-03, and KC-04) and also from the state of Illinois and other sources.

Table III.1 Nanosciences and Nanotechnology — Center for Nanoscale Materials ($ in millions BA, personnel in FTE)[a]

	FY02	FY03	FY04	FY05	FY06	FY07	FY08
Costs							
Operating[b]	0.4	1.0	7.8	12.3	17.3	17.3	17.3
Capital Equipment	-	6.8	18.1	18.1	-	-	-
Construction[c]	2.0	17.0	17.0	-	-	-	-
Total	2.4	24.8	42.9	30.4	17.3	17.3	17.3
Direct Personnel	-	4.0	30.0	46.0	59.0	59.0	59.0

[a]Argonne's nanoprobe beamline was approved for funding by DOE in FY02. Other parts of the CNM will be funded starting in FY03.

[b]Not included here is funding for in-house nanoscience research. Argonne will compete for this funding separately. This additional funding is expected to be similar in magnitude to the initiative's operating funding.

[c]The state of Illinois is funding construction of a building for the CNM.

2. Rare Isotope Accelerator

Opening of new frontiers for research in nuclear physics is expected through the acceleration of beams of unstable nuclei (rare isotopes). Critical information previously impossible to obtain includes (1) cross sections for astrophysical processes such as nucleosynthesis during and shortly after the Big Bang, energy-generating processes in stars, and heavy-element production via the r-process during supernova explosions; (2) qualitatively new and unexpected nuclear structure effects in nuclei far from stability, at their very limits of existence; and (3) completely new approaches to studies of nuclear decay, reactions, and structure. These opportunities have triggered considerable excitement in the scientific community worldwide.

Exploration at these frontiers will require extension of today's technical capabilities and facilities. This need and its scientific basis have been discussed thoroughly in a number of forums in the past decade, both in the United States and abroad, including the 1999 National Research Council's Committee on Nuclear Physics. Most recently, the compelling scientific opportunities offered by research with rare isotopes led the DOE-National Science Foundation Nuclear Science Advisory Committee (NSAC) in its *2002 Long Range Plan for Nuclear Science* to recommend the Rare Isotope Accelerator (RIA) as the field’s highest priority for major new construction and to conclude that RIA is required to ensure U.S. leadership in the areas of nuclear structure and nuclear astrophysics.

In collaboration with Michigan State University and other U.S. research institutions, Argonne developed a facility concept that will achieve the physics goals set forth by NSAC. The facility is currently envisioned to have a construction cost of approximately $650 million (in FY 2002 dollars) and a total project cost of under $1 billion (BA). Technology development related to RIA is currently under way at eight institutions, including both universities and national laboratories. The expectation is that the RIA project itself will also involve a national team. The preliminary budget profile in Table III.2 is for the entire project and team. Argonne is working with the research community to organize the RIA team and prepare a preconceptual design report.

In parallel with consideration of the fundamental science to be pursued, Argonne’s design for RIA has aroused significant interest in the technological applications of the rare isotopes to be created. Two workshops on potential applications were held in 2000, and interest in the facility continues to grow. In addition to potential applications to research in materials science, biology, and medicine, RIA has an important national security role identified in the science-based stockpile stewardship program.

Argonne’s concept for RIA is based on two accelerators. It uses a flexible approach for the primary production accelerator, which will be a high-power superconducting heavy-ion linac. The heavy-ion driver can deliver beams of any element from hydrogen to uranium, so a variety of production mechanisms can be selected to optimize rare isotope yields. One mechanism, heavy-ion fragmentation, can be used with a magnetic fragment separator and a new kind of fast gas catcher. This mechanism operates independently of the chemical properties of the exotic species being used. Argonne’s approach to RIA also capitalizes on the capabilities of the Laboratory’s existing state-of-the-art heavy-ion accelerator — ATLAS (Argonne Tandem-Linac Accelerator System) — as the postaccelerator. ATLAS is unique in the world in its ability to provide intense, high-quality, continuous-wave (100% duty cycle), heavy-ion beams for all elements up to and including uranium. ATLAS has excellent transverse and longitudinal phase space properties, and it excels in beam transmission and timing characteristics. These capabilities are important for nuclear structure investigations and astrophysics experiments, where the beam quality requirements are especially stringent.

Preliminary estimates of effort, time lines, and cost suggest that this major new facility can be constructed at Argonne within about five years, following approximately two years of detailed facility design. A preliminary funding profile is specified in Table III.2. The profile assumes that DOE approves the mission need statement for the project in 2002 or early 2003. Funding is being sought from the Nuclear Physics (KB-02) program. A major challenge is to increase DOE’s total nuclear physics budget sufficiently to allow RIA to proceed.

Table III.2 Rare Isotope Accelerator
($ in millions BA, personnel in FTE)

	FY02	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10
Costs									
Operating	2.8	3.5	11.0	5.0	3.0	13.0	31.0	45.0	63.0
Capital Equipment	-	-	-	-	-	3.0	10.0	15.0	20.0
Construction	-	-	-	27.0	85.0	140.0	216.0	186.0	114.0
Total	2.8	3.5	11.0	32.0	88.0	156.0	257.0	246.0	197.0
Direct Personnel	8.0	10.0	35.0	70.0	120.0	200.0	250.0	250.0	300.0

3. Functional Genomics

Recent developments in genome-scale DNA sequencing, high-throughput analytical tools, and computing technology have made feasible the genome-wide analysis of biomolecular function. Construction of a complete functional map of cellular behavior now appears to be achievable. Functional analysis of the thousands of proteins and other macromolecules needed for a comprehensive analysis of even the simplest prokaryote is a significant technological challenge that will require substantial enhancement of currently available experimental and computational capabilities. The amount of data needed to functionally characterize an organism greatly exceeds that required to sequence its genome. Furthermore, unlike genome sequencing, functional analysis requires multiple high-throughput experimental technologies and novel computational approaches.

Nevertheless, the comprehensive characterization of biomolecular function has huge potential payoffs. It will provide the basis for developing entirely new strategies for modulating cellular activities and engineering novel cellular capabilities. These opportunities can provide the basis for novel solutions to problems associated with the DOE science mission, and they will be particularly important for advancing the DOE national security mission through the study of organisms used as biowarfare agents. More broadly, the resulting capabilities will enable major benefits for environmental management, human health, and general economic productivity.

To help seize these opportunities, Argonne is continuing a major Laboratory initiative to undertake the large-scale functional characterization of genomes and thereby advance the goals of DOE's Genomes to Life program. The Functional Genomics initiative comprises three components: structural genomics, high-throughput biochemistry, and bioinformatics. The structural genomics component will evolve from the crystallographic resources of Argonne's Structural Biology Center (SBC) — one of the best facilities in the world for collecting high-resolution data from crystals of macromolecules and macromolecular complexes. Meeting the needs of this initiative will require greater throughput at the SBC, which can be achieved by enhancing existing detectors and upgrading optics and robotics capabilities.

The high-throughput biochemistry component of this initiative will develop through the growth of facilities and capabilities originally created for the Midwest Center for Structural Genomics (MCSG; funded by the National Institutes of Health [NIH]). The MCSG has robotic facilities for high-throughput cloning, expression, and purification of proteins. Significant expansion of those robotic facilities will be required for production of proteins at a rate adequate for the Functional Genomics initiative.

The initiative's informatics component will encompass computational structural biology and development of novel genome and proteome databases that support high-throughput experimentation. Integrating the massive amounts of data to be generated by the Functional Genomics initiative with the vast amounts of data accumulating in public databases throughout the world will be a significant challenge in itself.

Argonne has sought input on the development of strategies and procedures for this initiative throughout the research community. In September 2001 Argonne hosted a workshop on the challenges of integrating genome and proteome databases. In November 2002 the Laboratory will hold a workshop on the use of structural genomics for functional analyses of macromolecules. Additional workshops addressing other aspects of the program are being planned.

This initiative will take advantage of a number of important existing resources at Argonne and the University of Chicago. The SBC at the APS will be key for the production of high-resolution images of gene products. Such high-resolution images are the best way to link the sequence information generated by genome projects to the functional data that will be generated by the Functional Genomics initiative. Resources at the APS and the IPNS will be used for small-angle scattering studies of macromolecular complexes (molecular machines) that will be identified by protein-protein interaction mapping and generated in high-throughput protein production facilities. Protein chips for the study of protein-protein interactions will be developed in cooperation with the Laboratory's biochip program (Section IV.A.2.f). Studies of gene expression will be carried out in partnership with biochip facilities at the University. Finally, Argonne computer scientists will create a computational environment for information management and for analysis and integration of functional data. Computer simulations are essential to the development of systems biology capabilities. The Functional Genomics initiative will include a major effort to advance the systems biology of prokaryotes by using simulation.

To develop comprehensive functional information on whole organisms, Argonne will both enhance its existing capabilities and establish new capabilities. Existing resources for protein production will be enhanced. Novel resources for high-throughput mapping of protein-protein interactions will be established, as will facilities for identifying high-affinity, high-specificity ligands for all gene products and for the biochemical and biophysical characterization of protein function (e.g., enzyme assays). To house these resources, the Laboratory has proposed that the state of Illinois fund construction of a new facility providing over 40,000 square feet of laboratory space, including space for high-throughput crystallization facilities. To develop state-of-the-art intermediate-voltage cryoelectron microscopy and associated image processing capabilities, Argonne will partner with the University of Chicago. In general, the facilities developed for this initiative will serve the entire research community. They will provide researchers from universities and industry with a very broad range of capabilities needed to study molecular processes in the cell.

Argonne's Functional Genomics initiative is designed to advance the goals of the Genomes to Life program of DOE's Office of Biological and Environmental Research (DOE-BER). The four goals of this program are to (1) identify and characterize the molecular machines of life, (2) characterize gene regulatory networks, (3) characterize the functional repertoire of complex microbial communities in their natural environments at the molecular level, and (4) develop the computational capabilities needed to advance understanding of complex biological systems and predict their behavior. Key to this program is a systems biology approach to understanding how molecular machines and other cellular components function together in a living system. Developing capabilities for comprehensive functional characterization of entire genomes is critical to the success of this program.

Elements of Argonne's Functional Genomics initiative should attract sponsorship from NIH. Table III.3 describes the overall resources required, including the efforts of computer scientists, environmental scientists, and APS staff, as well as biologists working in the areas of structural and functional genomics. The increase in resources from FY 2002 to FY 2005 reflects anticipated expansion of computational and robotics capabilities and NIH funding to support sector development and operation of an experimental station (the GM/CA-CAT) at the APS. These increases will support multiple Argonne research divisions working — in the areas of computation, engineering, and molecular biology — to determine the molecular structure and function of macromolecular complexes. DOE funding will be sought from DOE-BES (Energy Biosciences; KC-03) and from DOE-BER (KP-11), including the latter office's new Genomes to Life program.

Table III.3 Functional Genomics
($ in millions BA, personnel in FTE)[a]

	FY02	FY03	FY04	FY05	FY06	FY07	FY08
Costs							
Operating[b]	12.2	14.3	16.5	17.7	18.6	19.5	20.5
Capital Equipment	0.4	1.5	1.3	1.3	1.6	1.6	1.6
Construction[c]	-	-	2.0	16.0	16.0	-	-
Total	12.6	15.8	17.8	19.0	20.2	21.1	22.1
Direct Personnel	23.7	55.2	67.3	69.4	69.4	69.4	69.4

[a]Resource projections include funding from the National Institute of General Medical Sciences for the MCSG, plus anticipated funding from NIH, DOE-BER, and other organizations.

[b]Includes anticipated funding from NIH and the National Institute of General Medical Sciences for development of the GM/CA-CAT sector at the APS (enclosures, utilities, and undulators and other insertion devices).

[c]Funding of construction has been proposed to the state of Illinois.

4. Petaflops Computing and Computational Science

Argonne's Petaflops Computing and Computational Science initiative builds on the Laboratory's existing long-term base program in mathematics and computer science, which is supported by DOE's Office of Advanced Scientific Computing. DOE and other agencies support work in the areas of mathematical software, parallel programming tools, advanced visualization systems, grid computing and distributed systems, collaboration technologies, scalable systems software, and performance analysis and modeling. Strong internal and external scientific collaborations tie this computer science research work to diverse applications in biology, high energy physics, climate modeling, computational chemistry, chemical engineering, subsurface modeling, biomedical computing, astrophysics, and other areas. Argonne plans to continue building its base activities in fundamental computer science and mathematics while increasing its computational science efforts by applying advanced computing to leading-edge scientific investigations, both theoretical and experimental.

Argonne's Petaflops Computing and Computational Science initiative aims to accelerate progress in these directions through three major components: (1) a laboratory-wide computational science program, (2) a targeted R&D program, and (3) a new advanced computation building:

- The *Laboratory-wide computational science program* will provide expertise and midrange computing resources to the Laboratory. The purpose is to enable all research groups at Argonne to begin to apply state-of-the-art computational methods to their work and to help them prepare to take advantage of emerging large-scale computing opportunities. Current exploratory efforts involve all the Laboratory's scientific and engineering programs.

- The *targeted R&D program* will lead to deployment of a petascale system (i.e., one capable of 10^{15} operations per second) by 2006 and will include development of next-generation modeling capabilities in diverse scientific applications ranging from the life sciences and nanosciences to energy systems and the environment. The program will take advantage of the development of advanced analysis techniques for constructing predictive models of overall systems performance; recent advances in computer-aided design tools for applying an integrated software-hardware co-design approach to large-scale systems; and the expected availability by 2005 of the billion-transistor chips needed to build petascale systems.

- The *new advanced computation building* will support integrated research in mathematics, computer science, computational science and theory, collaborative research with industry, and joint programs with the University of Chicago (e.g., the Computation Institute). The building will include a large-scale computer room capable of housing a petaflops computing system and will incorporate digital collaboration technologies to support distributed meetings and collaboratories.

During FY 2002 Argonne made substantial progress in several areas that support the Petaflops Computing and Computational Science initiative. A newly established collaboration with IBM's advanced architecture group has begun studying design options for specific classes of applications. A collaboration involving Argonne computer scientists and computational biologists and researchers at the University of Chicago aiming to advance large-scale computing in systems biology has begun to analyze model organisms and to design a whole-cell modeling system targeting petascale architectures. Laboratory researchers in computational nanoscience have begun development of an integrated simulation environment that combines models at multiple temporal and spatial scales; the researchers are also developing a virtual fabrication line simulation capability that will complement facilities being deployed in the Center for Nanoscale Materials (see Section III.A.1).

Resources required for the Petaflops Computing and Computational Science initiative are specified in Table III.4. Included are costs for facilities and for a concomitant increase in personnel (systems staff, postdoctoral researchers, scientific programmers, and permanent research staff). Funding will be sought from the

Table III.4 Petaflops Computing and Computational Science ($ in millions BA, personnel in FTE)

	FY02	FY03	FY04	FY05	FY06	FY07	FY08
Costs							
Operating	2.0	4.0	12.0	16.0	24.0	24.0	24.0
Capital Equipment	-	1.0	2.0	4.0	40.0	40.0	40.0
Construction[a]	-	-	-	4.6	4.6	4.8	5.0
Total	2.0	5.0	14.0	24.6	68.6	68.8	69.0
Direct Personnel	10.0	20.0	60.0	80.0	120.0	120.0	120.0

[a]Detailed planning for the advanced computation building will be done in FY02. Calculation of construction costs assumes third-party financing for FY03 and FY04, with leasing to begin in FY05. The calculated leasing cost is based on 220,000 square feet at $20 per square foot, plus overhead at approximately 1.15%.

Mathematical, Information, and Computational Sciences Division (KJ-01) and from other sponsors within DOE's Office of Science.

B. Energy

1. Advanced Nuclear Fuel Cycle

The need to produce increasing amounts of energy and still reduce the burden of energy production on the environment dictates that nuclear energy will have a major role in the future. Nuclear energy on the required scale cannot be realized without addressing problems associated with spent fuel disposition and nuclear nonproliferation. The best way to address those two problems is through an advanced nuclear fuel cycle that returns fuel to the reactor and produces a more benign waste form.

The requirement for an advanced nuclear fuel cycle is recognized in the May 2001 report of the National Energy Policy Development Group: "The United States should reexamine its policies to allow for research, development, and deployment of fuel conditioning methods (such as pyroprocessing) that reduce waste streams and enhance proliferation resistance." This need was also recognized more recently in the May 2002 summit meeting between President Bush and Russian President Putin. The two presidents agreed that their governments see promise in advanced technologies for nuclear reactors and nuclear fuels that would significantly reduce the volume of waste produced by civilian reactors, would be highly proliferation resistant, and could be used to reduce excess stocks of weapons-grade plutonium and other dangerous nuclear materials.

Argonne has been collaborating with DOE-Nuclear Energy, other national laboratories, industry, and international partners to formulate an Advanced Nuclear Fuel Cycle initiative. The initiative's objective is to develop the technology base for a new globally secure, sustainable nuclear regime that will allow nuclear power to become a publicly acceptable, growing part of the energy supply mix in the United States and abroad. Such a regime would also be marked by reduced and stabilized inventories of spent nuclear fuel, secure management of problematic nuclear materials, enhanced proliferation resistance, and restoration of U.S. global leadership in nuclear technology.

Working with international partners, the Advanced Nuclear Fuel Cycle initiative would demonstrate the technologies and nuclear systems needed to bring about the desired new nuclear regime. The two key technologies and systems that must be developed and demonstrated are a closed, proliferation-resistant fuel cycle and an advanced fast-neutron-spectrum facility. Argonne proposes to develop and demonstrate a fuel cycle based on pyroprocessing and a fast-spectrum nuclear reactor.

The Laboratory's Advanced Nuclear Fuel Cycle initiative has four components: (1) oxide fuel reduction and actinide recovery, (2) the demonstration of reactor transmutation, (3) a prototype pyroprocessing facility, and (4) the design of a prototype reactor.

Oxide Fuel Reduction and Actinide Recovery

Pyroprocessing is now being used on a production basis at Argonne-West to treat spent fuel from the Experimental Breeder Reactor-II (EBR-II). However, the current system cannot process oxide spent fuel, nor can it separate and recover plutonium and higher actinides. Necessary advances are the development and demonstration of (1) a front-end process for reducing oxide fuel to metal suitable as input for electrorefining and (2) a process for recovering plutonium and other actinides for recycling into fast reactor fuel. Also required is completed qualification of the metal and ceramic waste forms for disposal in a repository. Those waste forms contain metals and fission products remaining after the separation and recovery of uranium, plutonium, and other actinides.

Demonstration of Reactor Transmutation

Demonstration of transmutation of actinides in a fast reactor requires fabrication of fuel containing actinides and irradiation of the fuel in a fast reactor to about 10% burnup. Such a demonstration will show that fuel containing actinides can be fabricated successfully in a remote process, that the fuel performs reliably in the reactor, and that the fuel has the necessary inherent safety characteristics. With no fast reactor operating today in the United States, the demonstration will require international collaboration.

Prototype Pyroprocessing Facility

As the third component of this initiative, Argonne proposes to design, construct, license, and operate a prototype spent-fuel pyroprocessing facility. This facility would have a capacity of 100 metric tons of heavy metal per year for light-water-reactor spent fuel. The objective is to demonstrate the technical and economic viability of pyroprocessing and fabrication of new fuel containing recycled actinides, at a scale giving high confidence in the economic viability of a full-scale commercial plant.

Design of a Prototype Reactor

Finally, Argonne proposes to conduct nuclear system R&D and design studies focusing on a fast reactor of about 300 MWe power rating that incorporates lessons learned about fast reactor technology from around the world, particularly lessons from Argonne's successful EBR-II program. International collaboration will facilitate the incorporation of worldwide lessons learned, and Argonne will seek partnerships with countries having significant experience with fast reactors and sustained interest in the technology, particularly Japan, France, and Russia.

Primary support for the Advanced Nuclear Fuel Cycle initiative will be sought from DOE-Nuclear Energy, Science and Technology (AF). Required resources are summarized in Table III.5.

Table III.5 Advanced Nuclear Fuel Cycle
($ in millions BA, personnel in FTE)

	FY02	FY03	FY04	FY05	FY06	FY07	FY08
Costs							
Operating	-	15.0	17.0	19.0	23.0	23.0	23.0
Capital Equipment	-	5.0	8.0	10.0	5.0	5.0	5.0
Construction	-	-	-	-	-	-	10.0
Total	-	20.0	25.0	29.0	28.0	28.0	38.0
Direct Personnel	-	80.0	90.0	95.0	100.0	100.0	100.0